

Costs and Benefits of Commissioning New and Existing Commercial Buildings

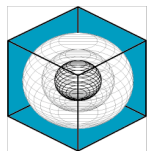
Building a Sustainable Campus Community
U.C. Santa Cruz, June 21, 2005



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Sponsors: U.S. Department of Energy • CEC-PIER



Commissioning (Cx) is *Quality Assurance*

(Green Buildings are not exempt from Murphy's Law)

- Articulating/verifying design intent
- Construction observation; warranty enforcement
--> Controlling first cost
- Identifying broken, disabled, or malfunctioning systems
- Optimizing performance (comfort, reliability, safety, energy)
- Training operators
- Enhancing safety and risk management

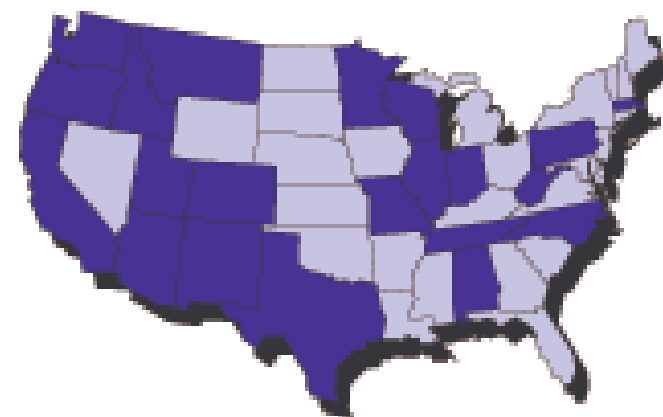
Project Objective and Methods

- **Objective:** Evaluate costs and benefits of Cx, understand energy savings opportunities from correcting design & operational problems
- **Methods:**
 - Gather data (real buildings)
 - Focus on energy; consider non-energy impacts (+/-)
 - Separate treatment of new and existing buildings
 - Standardize information (definitions, normalized energy prices, inflation). Has significant effect on results; allows inter-comparisons
 - Perform statistical and correlation analyses

>> About 200 fields of data collected <<

Resulting Sample Characteristics

- 224 buildings (175 projects), of which 150 are existing buildings and 74 are new construction
 - 19+ commissioning providers
 - Largest sample yet compiled
- Diversity of building types (heavy on public buildings)
- 30.4 million square feet across 21 states
 - Existing buildings: median 151,000 ft²
 - New construction: median 69,500 ft²
- \$17 million investment in commissioning
- Projects span two decades, but most done in the 1990s

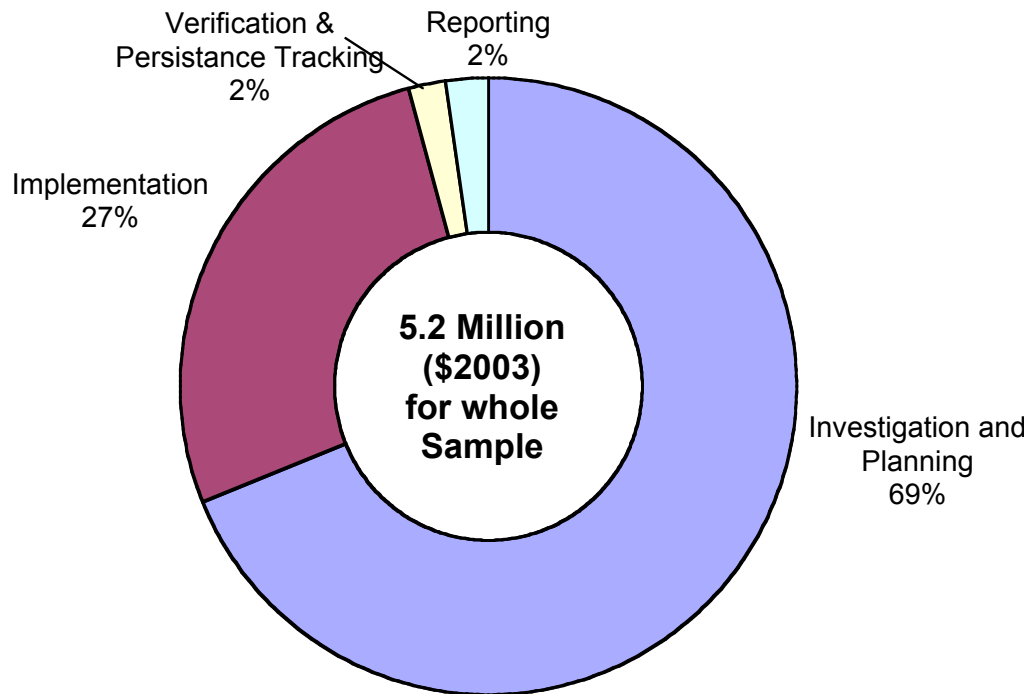


Top-level Findings (all values are medians)

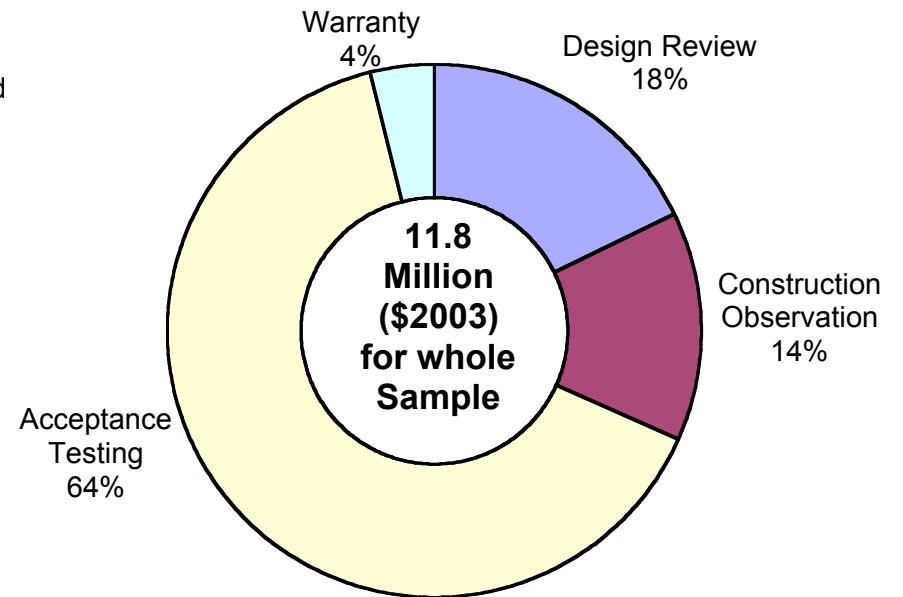
- Existing Buildings
 - Cost: \$0.27/ft² • NEBs: \$0.18/ft²
 - Deficiencies: 3500 (11 per building)
 - Whole-building energy savings: 15%
 - Payback time: 8 months
- New Construction
 - Cost: \$1.00/ft² • NEBs: \$1.24/ft²
 - Deficiencies: 3300 (28 per building)
 - Payback time: 4.8 years
- Cost-effective over range of energy intensities building types, sizes, and locations
- Most successful: energy-intensive buildings
- Cost-effective outcomes harder in small buildings

Cost Allocation

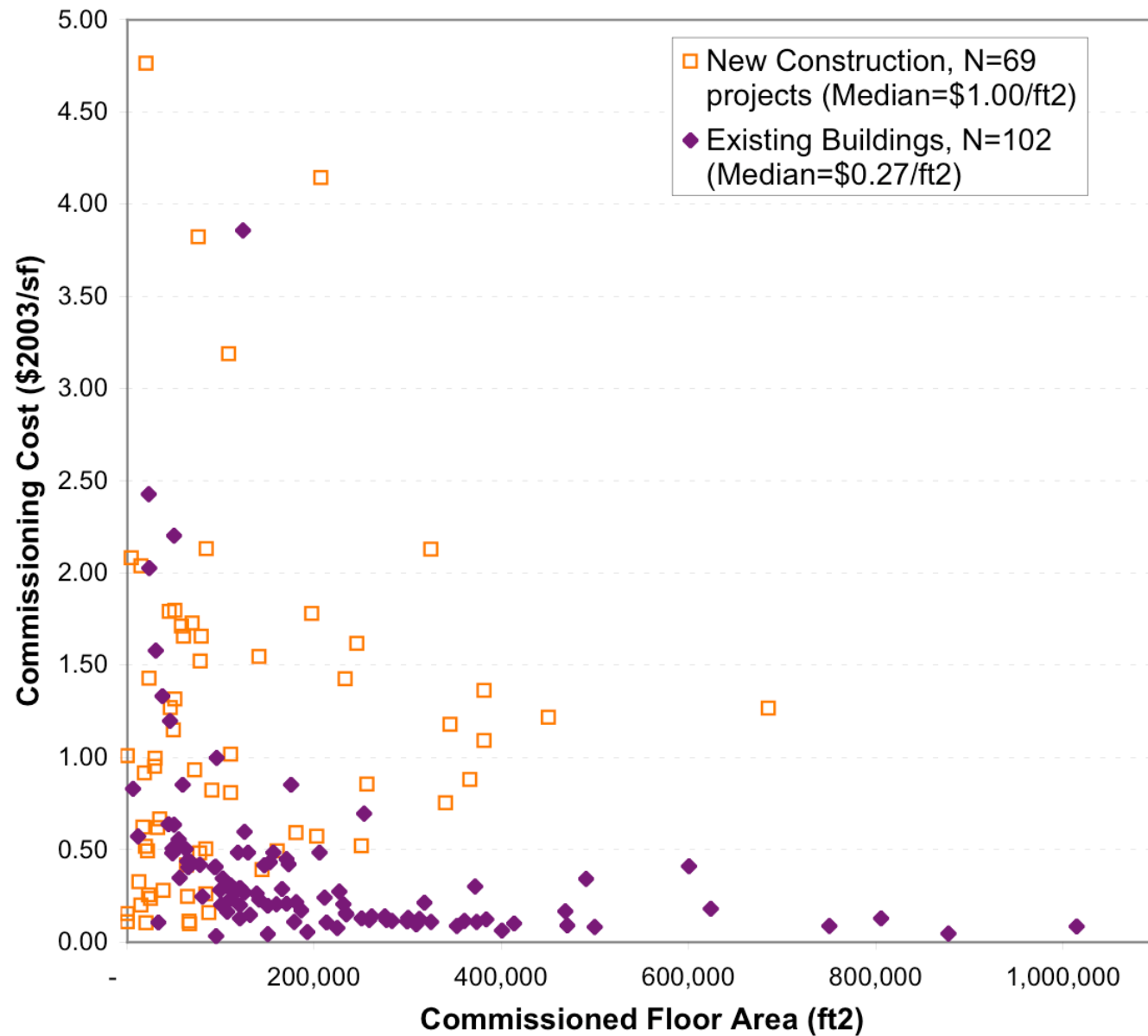
Existing Buildings (N=55)



New Construction (N=5)

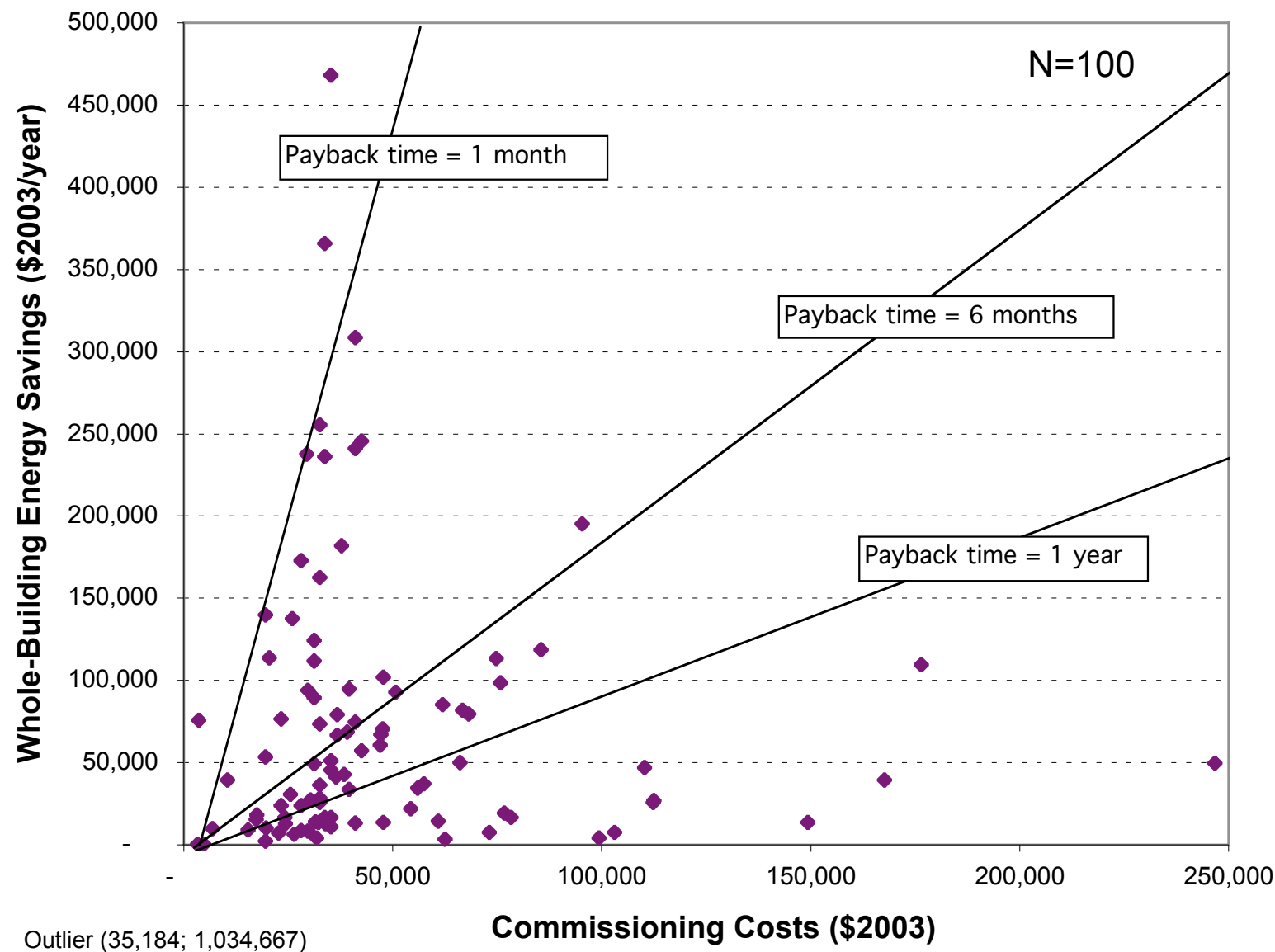


Normalized Costs



Payback Times: Existing Buildings

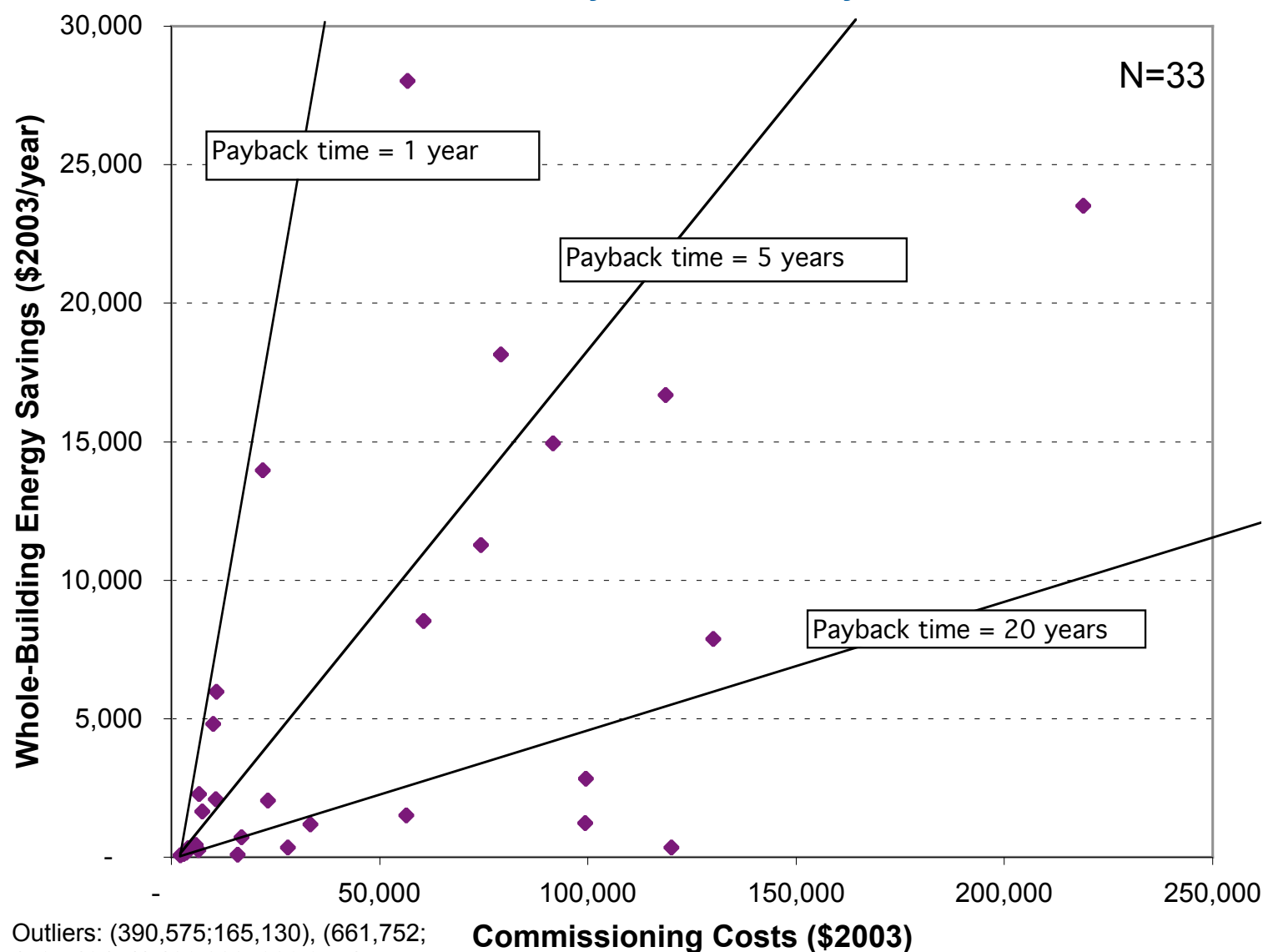
Median Payback Time = 0.7 years



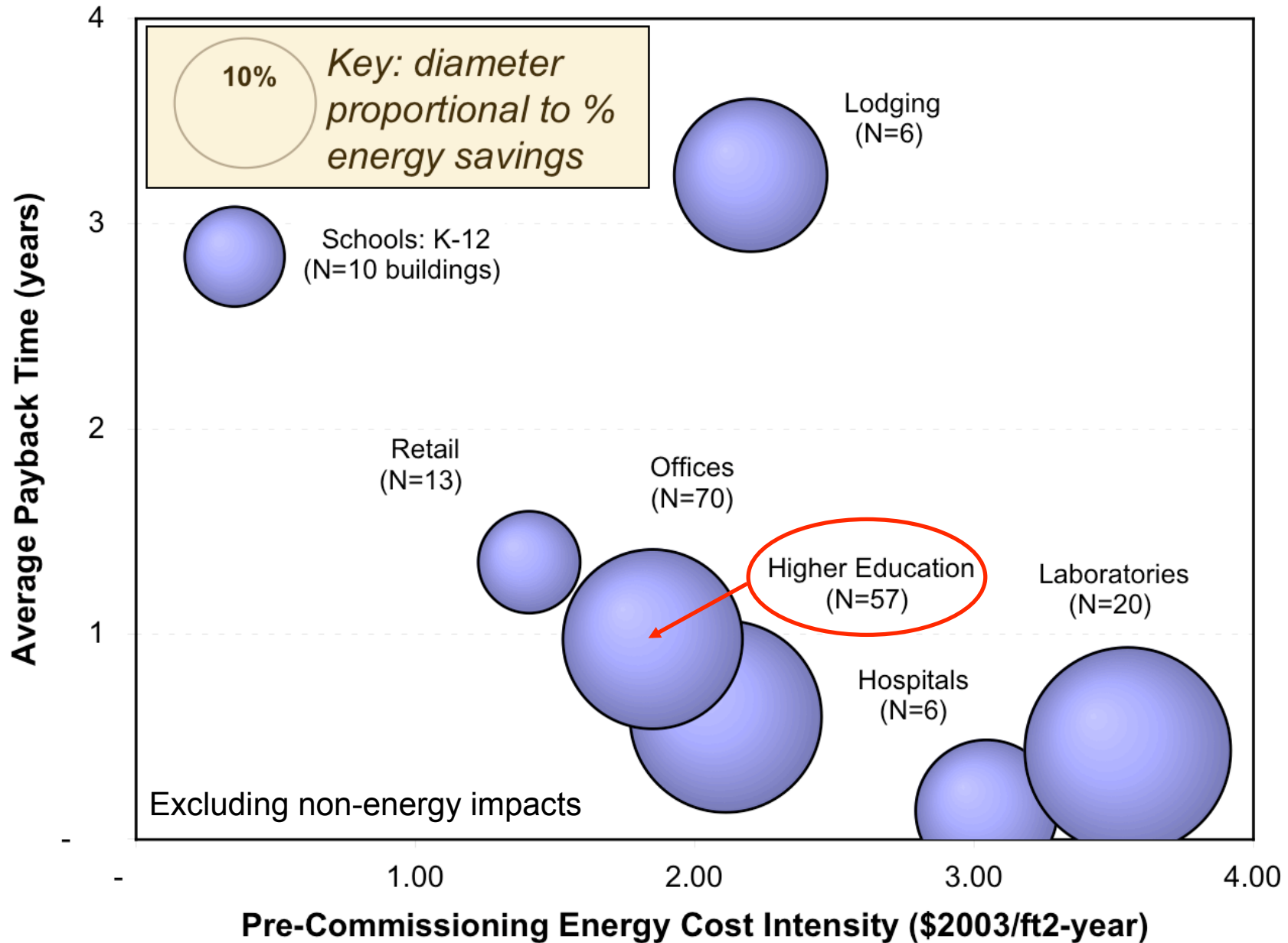
*Attractive
payback
times
across
range of
building
sizes*

Payback Times: New Construction

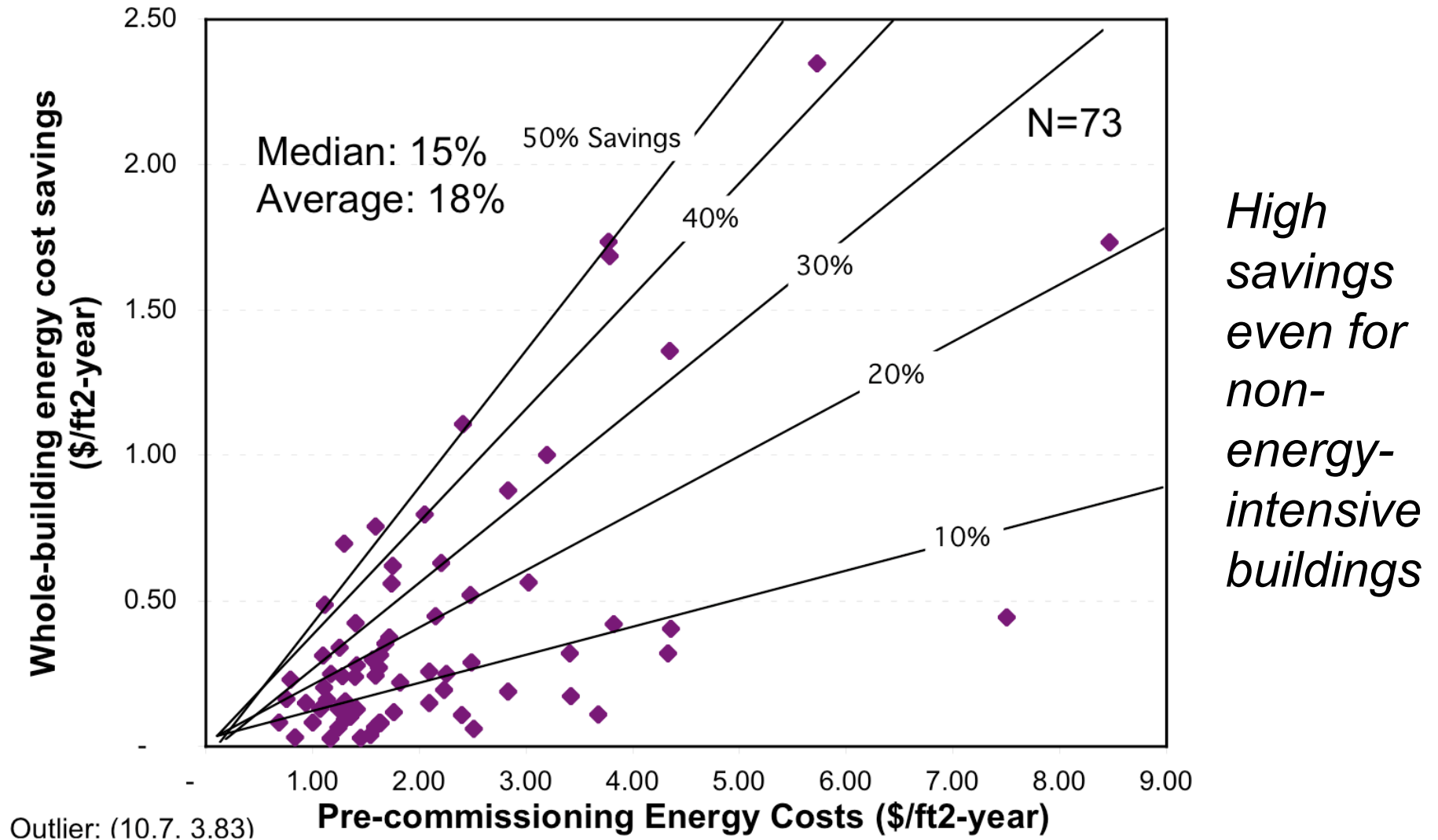
Median Payback Time = 4.8 years



Results Vary by Building Type

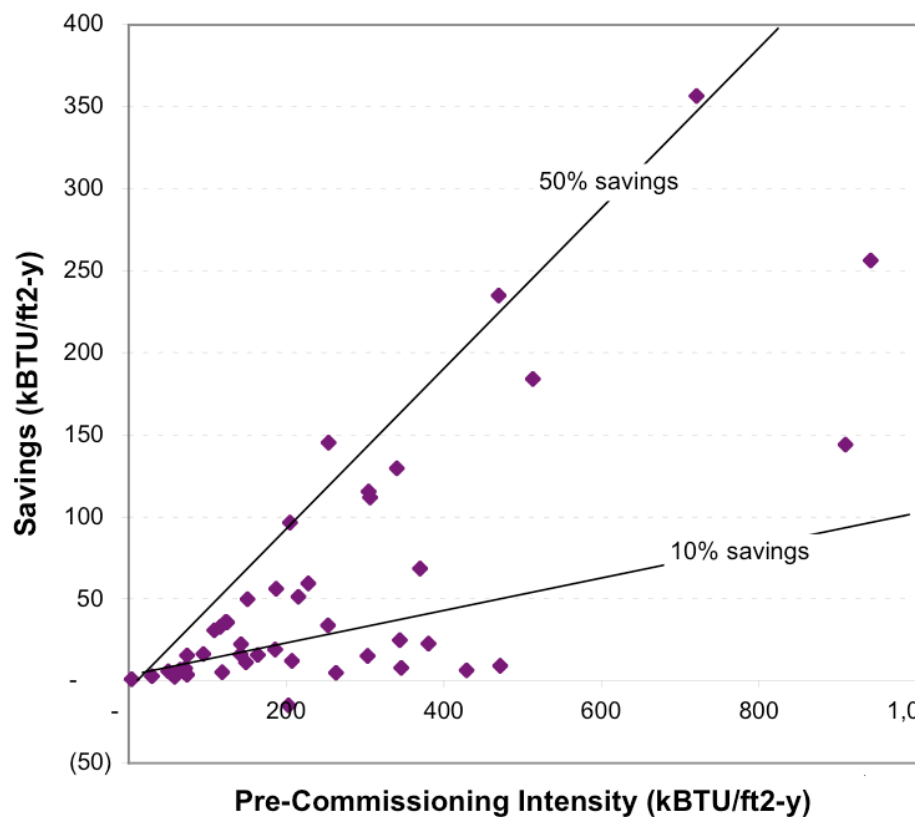


Up to 50% Whole-Building Energy Savings

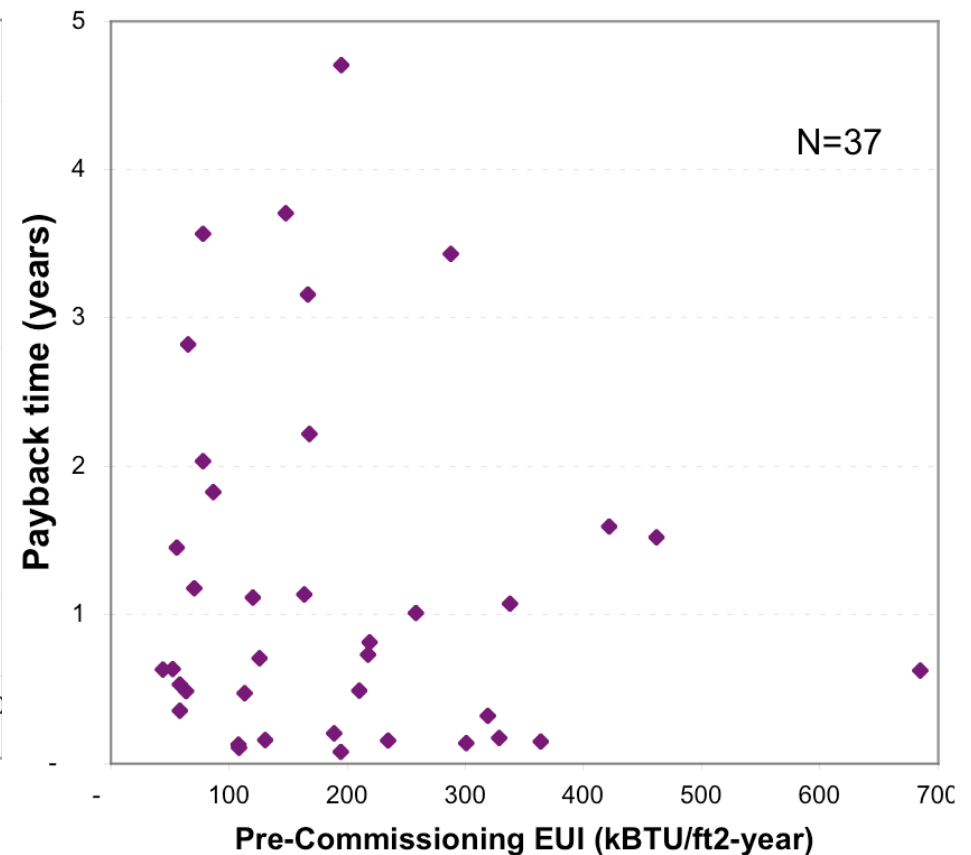


Energy Savings & Payback Times Independent of Pre-Cx Energy Intensities

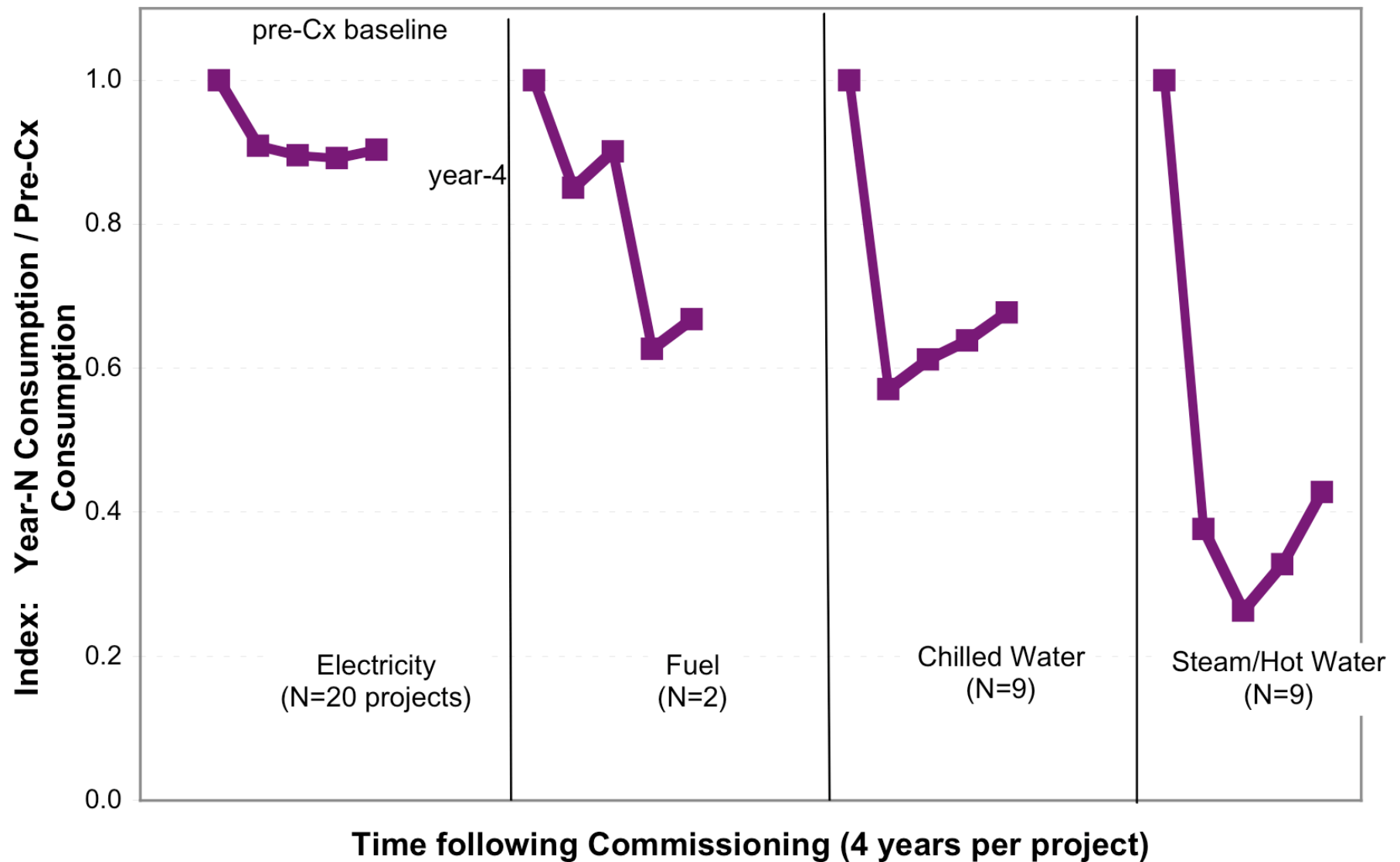
Total Energy Savings vs. Pre-Commissioning Intensities (Existing Buildings)



Payback Time vs. Pre-Retro-Commissioning EUI (Existing Buildings)

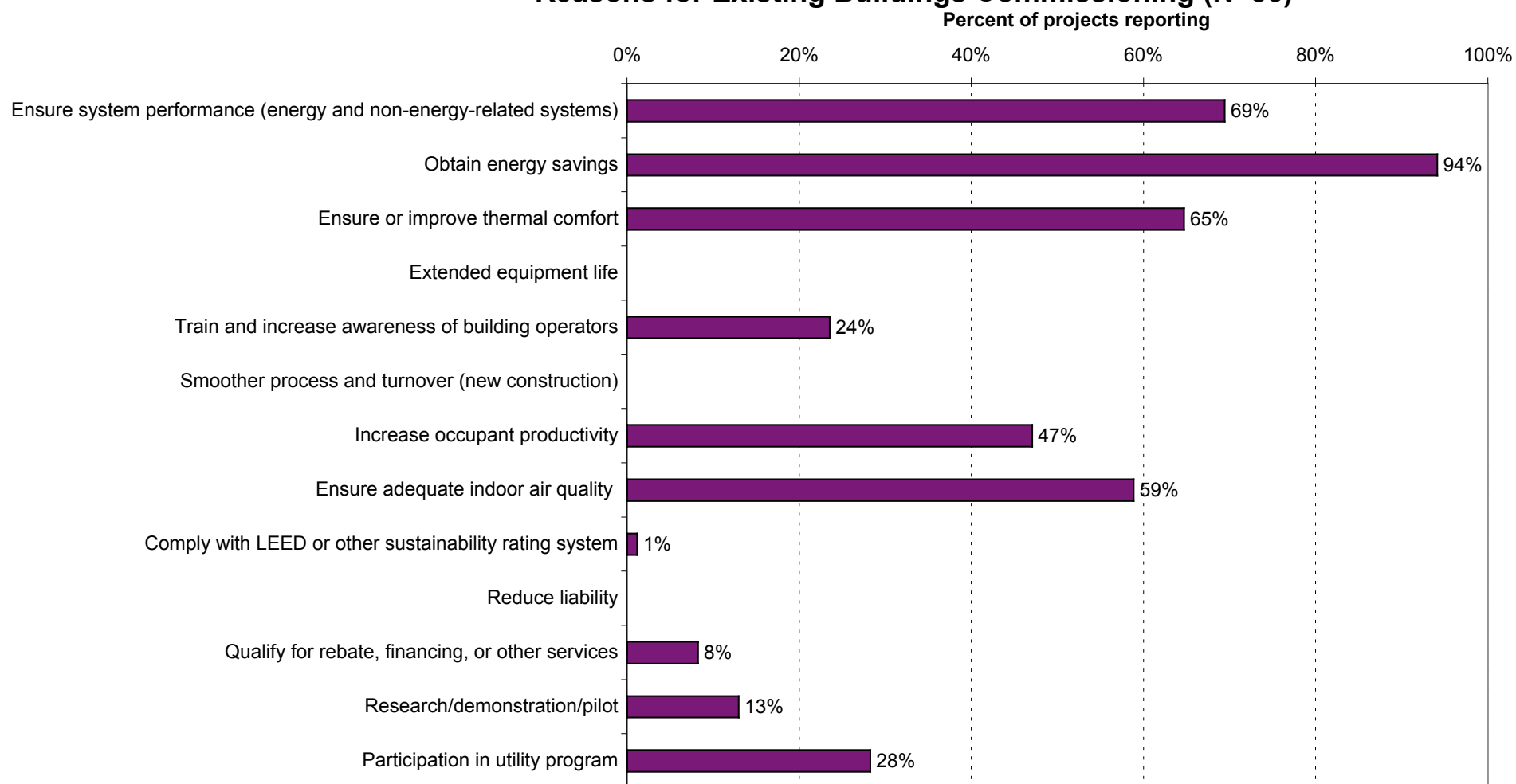


Emergence & Persistence of Energy Savings



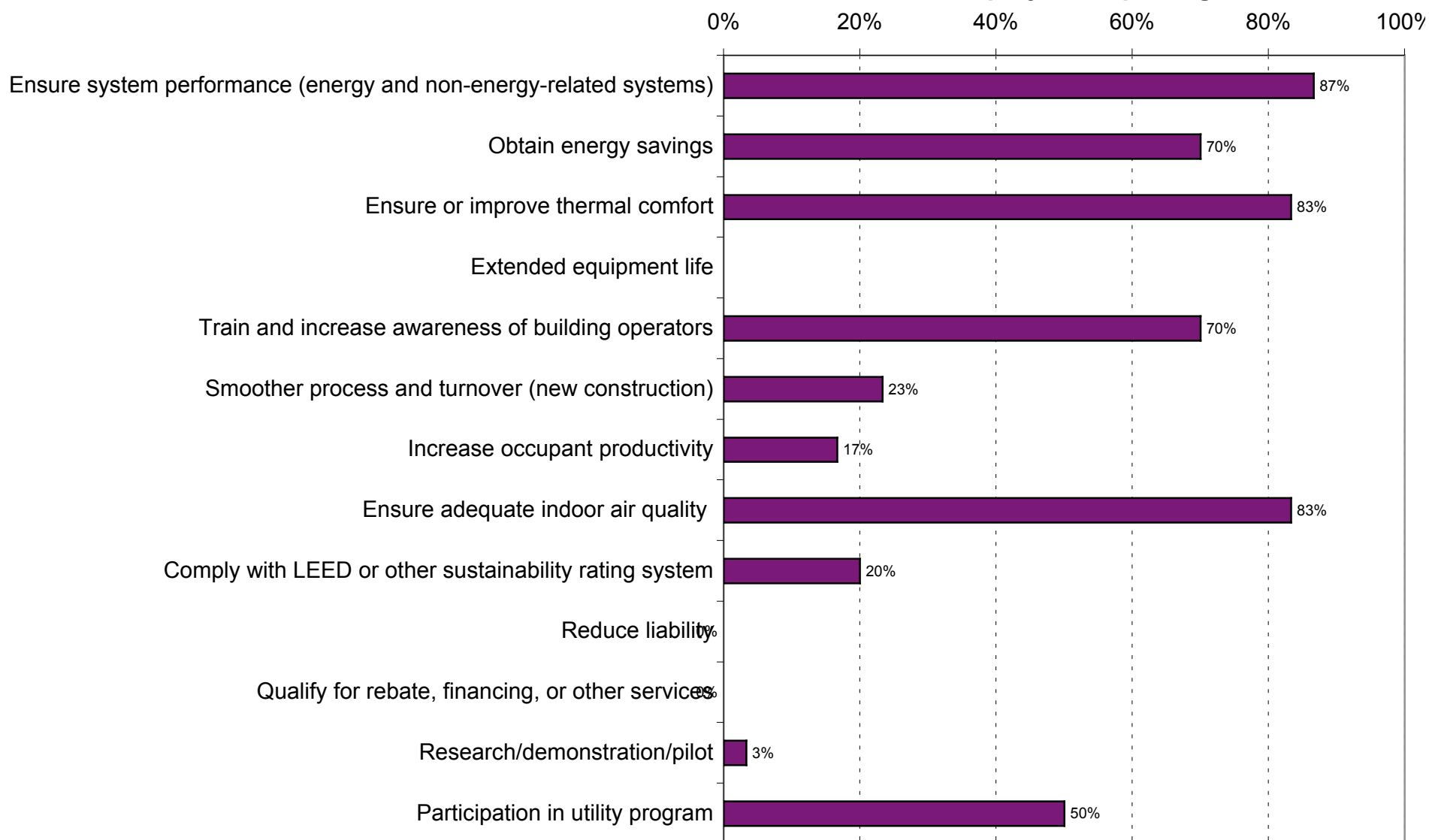
Drivers: Existing Buildings

Reasons for Existing Buildings Commissioning (N=85)

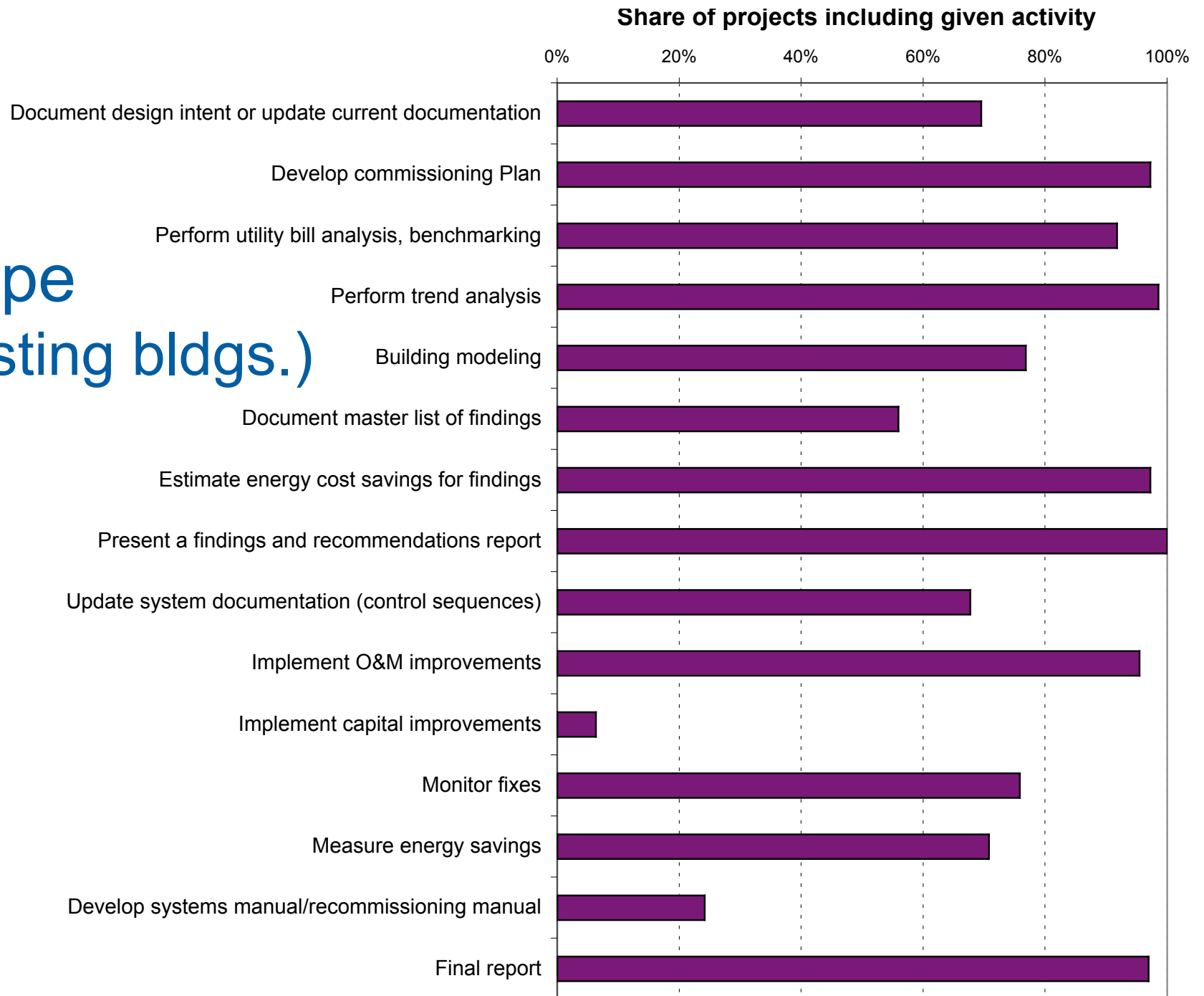


Drivers: New Construction

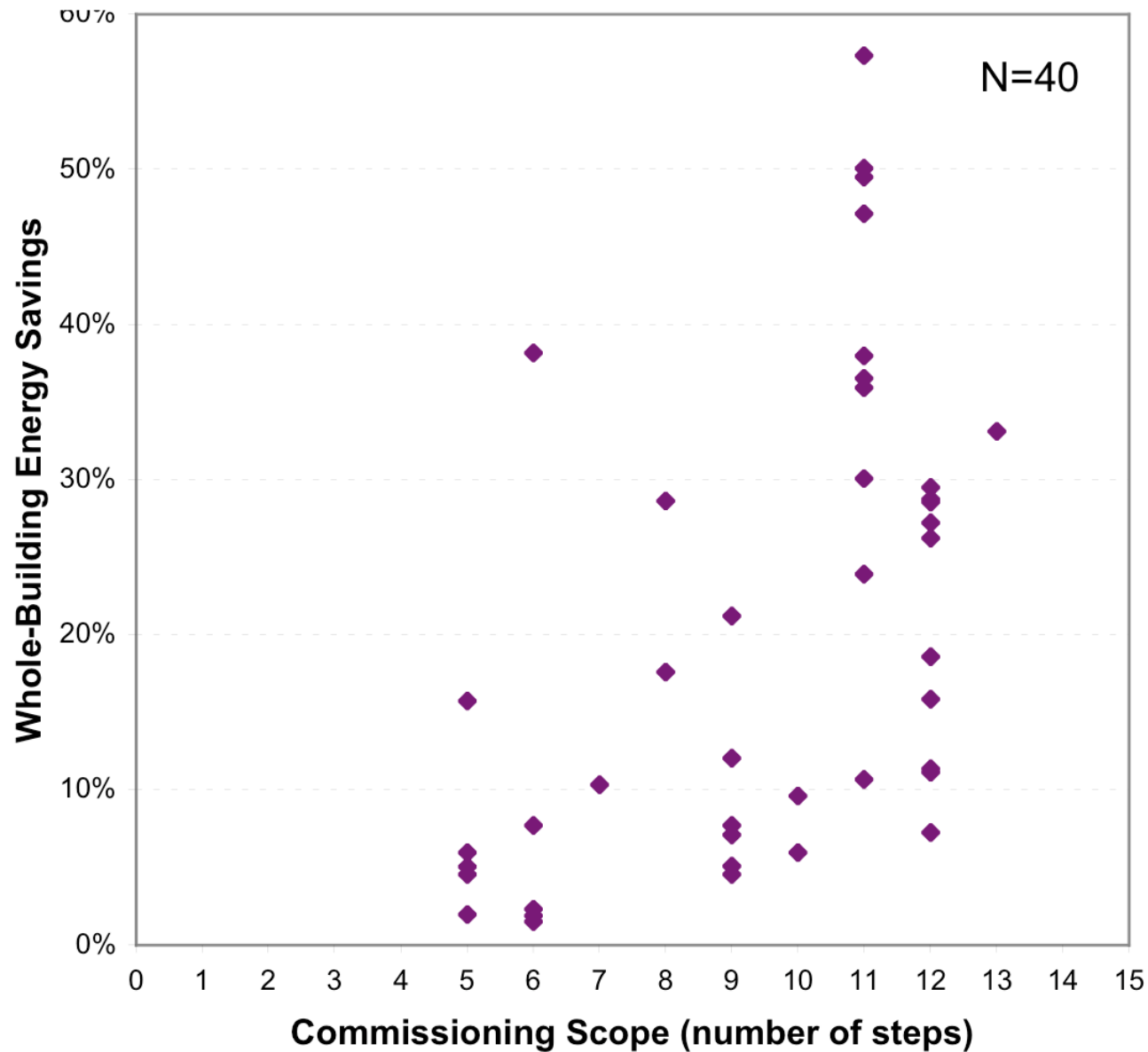
Reasons for New-Construction Commissioning (N=30) Percent of projects reporting



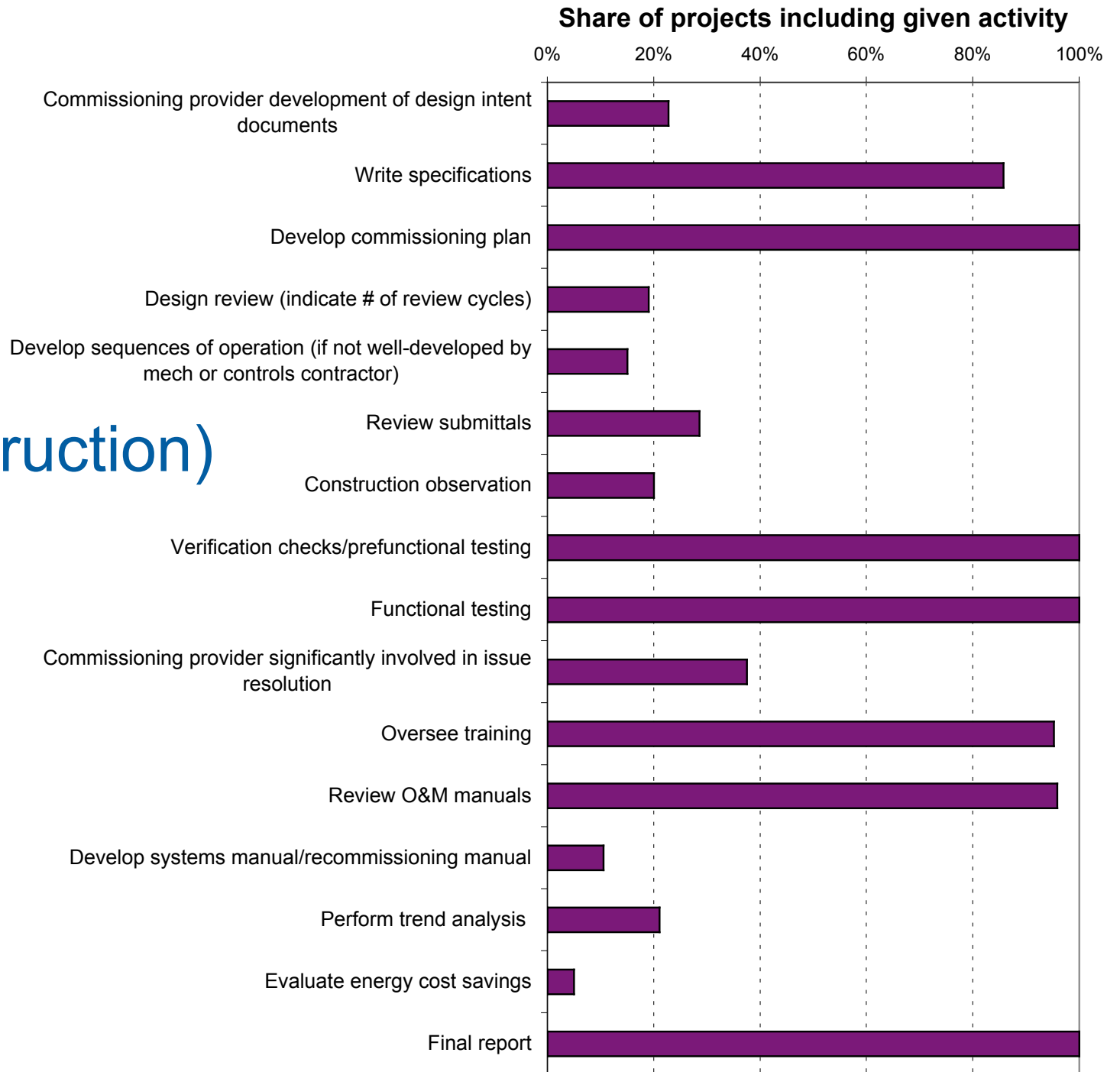
Scope (Existing bldgs.)



Savings Scale with Commissioning Scope

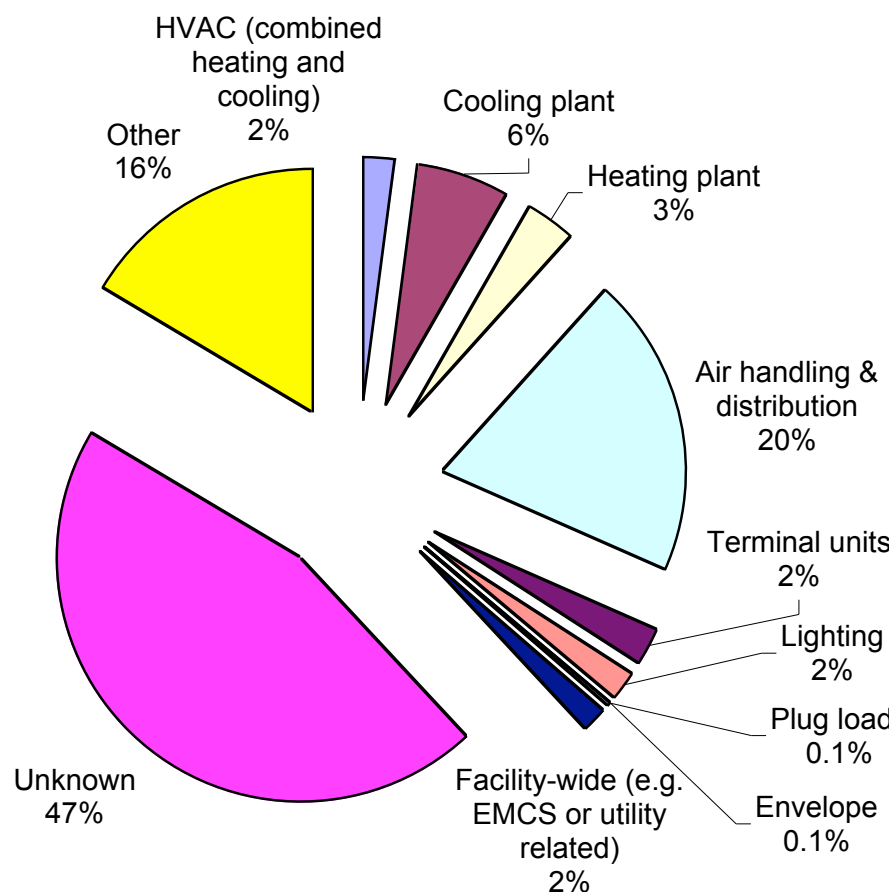


Scope (New construction)

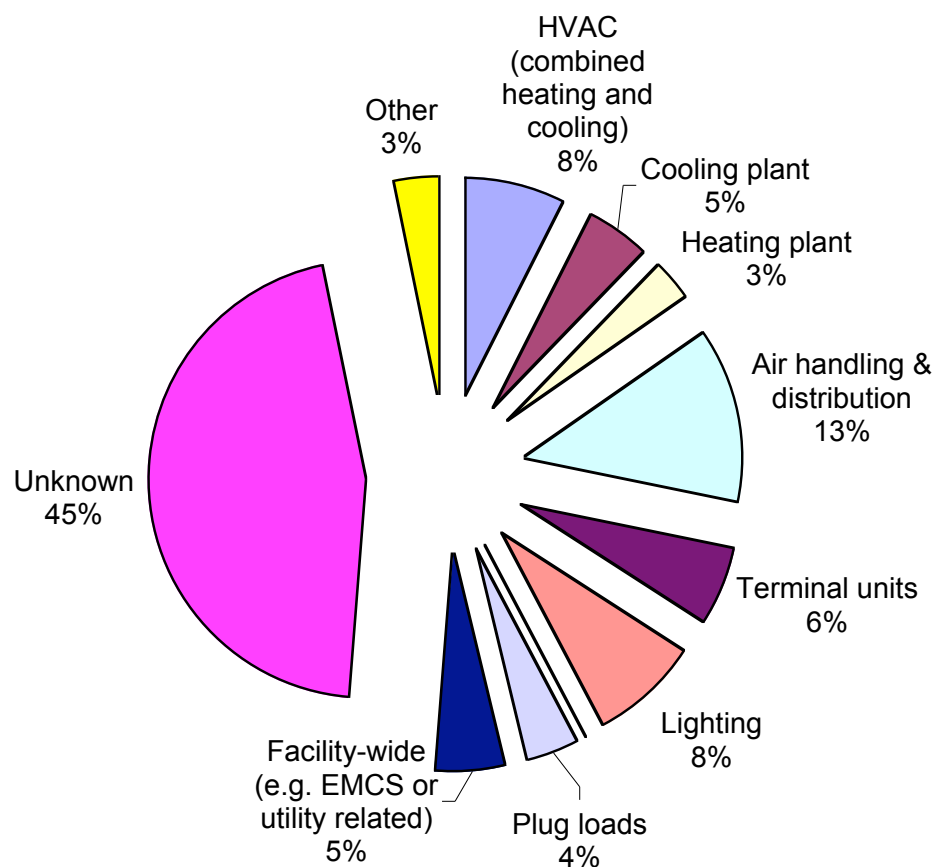


Deficiencies by Building System

**Number of Deficiencies Identified by Building System
(Existing Buildings, N = 3,500)**



**Number of Deficiencies Identified by Building System
(New Construction, N = 3,305)**



Measures Matrix

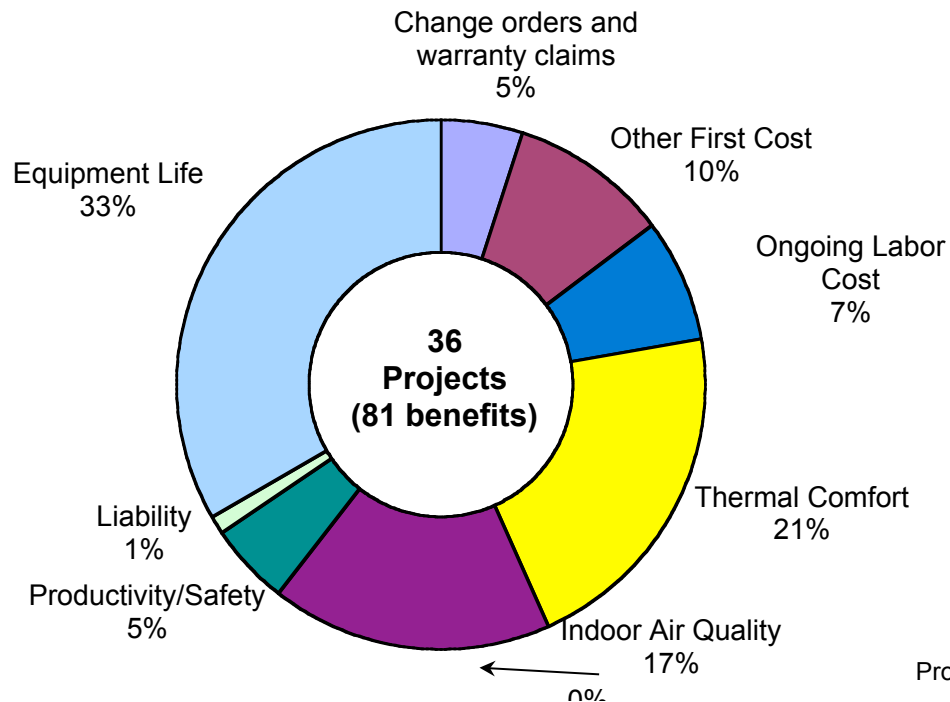
*Pairing of
deficiencies
(rows) and
corrective
measures
(columns)*

*69 projects;
702 measures*

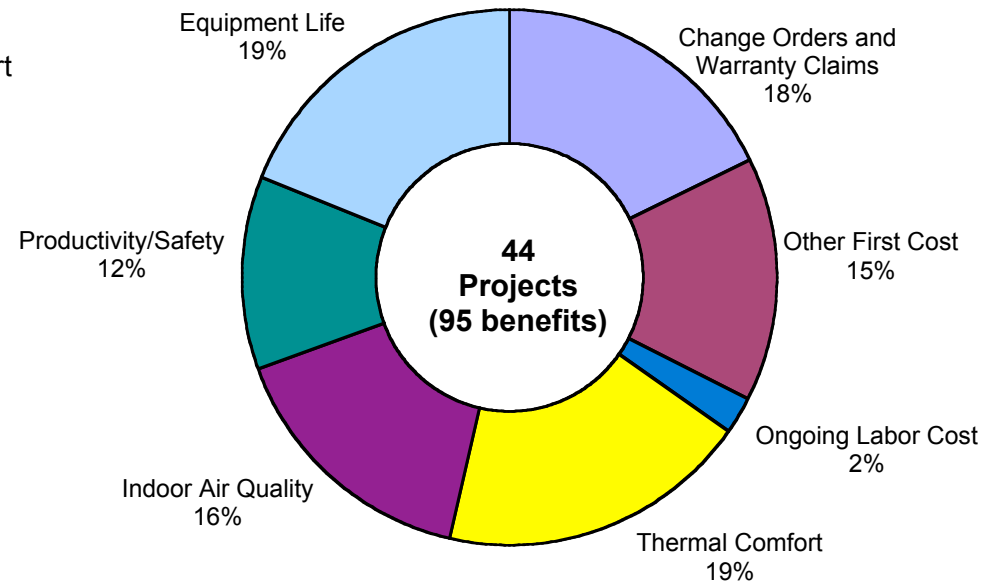
		Design, Installation, Retrofit, Replacement				Operations & Control									Maintenance					Deficiency unmatched to specific measure	Total
Deficiencies		Design change	Installation modifications	Retrofit/equipment replacement	Other	Implement advanced reset	Start/Stop (environmentally determined)	Scheduling (occupancy determined)	Modify setpoint	Equipment staging	Modify sequence of operations	Loop tuning	Behavior modification/manual changes to operations	Other	Calibration	Mechanical fix	Heat transfer maintenance	Filtration maintenance	Other		
		D1	D2	D3	D4	OC1	OC2	OC3	OC4	OC5	OC6	OC7	OC8	OC9	M1	M2	M3	M4	M5		
HVAC (combined heating and cooling)	V	0	2	8	1	1	1	5	3	1	5	0	0	2	5	7	1	5	2	12	61
Cooling plant	C	4	11	19	0	26	5	4	10	4	27	3	12	2	4	10	1	0	0	13	155
Heating plant	H	4	0	5	0	15	7	1	4	0	7	1	5	1	4	7	1	0	0	18	80
Air handling & distribution	A	15	9	19	3	80	9	21	25	4	24	12	14	6	40	27	3	4	2	40	357
Terminal units	T	1	3	2	1	4	0	3	14	0	4	1	2	1	7	10	0	0	0	8	61
Lighting	L	3	1	17	1	1	2	4	0	0	0	0	5	0	2	1	0	0	0	1	38
Envelope	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plug loads	P	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Facility-wide (e.g. EMCS or utility related)	F	2	3	2	0	1	0	7	0	0	1	1	7	2	2	2	1	0	0	3	34
Other	O	0	0	2	0	0	0	0	2	0	1	0	1	0	0	3	0	0	1	12	22
Deficiency unmatched to specific measure		10	9	7	0	2	2	1	29	2	7	2	4	1	12	10	0	0	0		809
Total		39	38	81	6	130	26	46	87	11	76	20	51	15	76	77	7	9	5	800	

Observed Non-Energy Impacts

Existing Buildings (N=55)



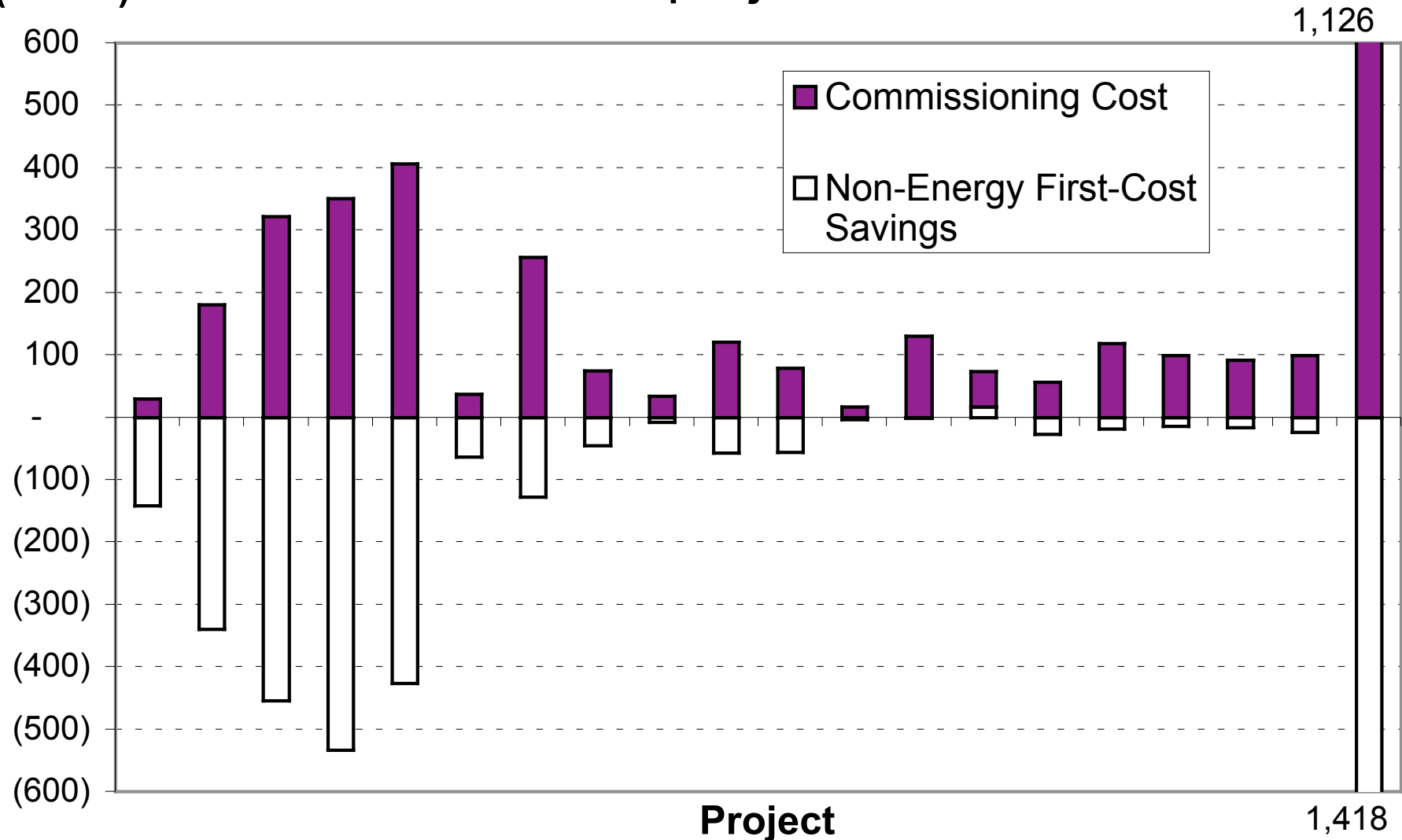
New Construction (N=5)



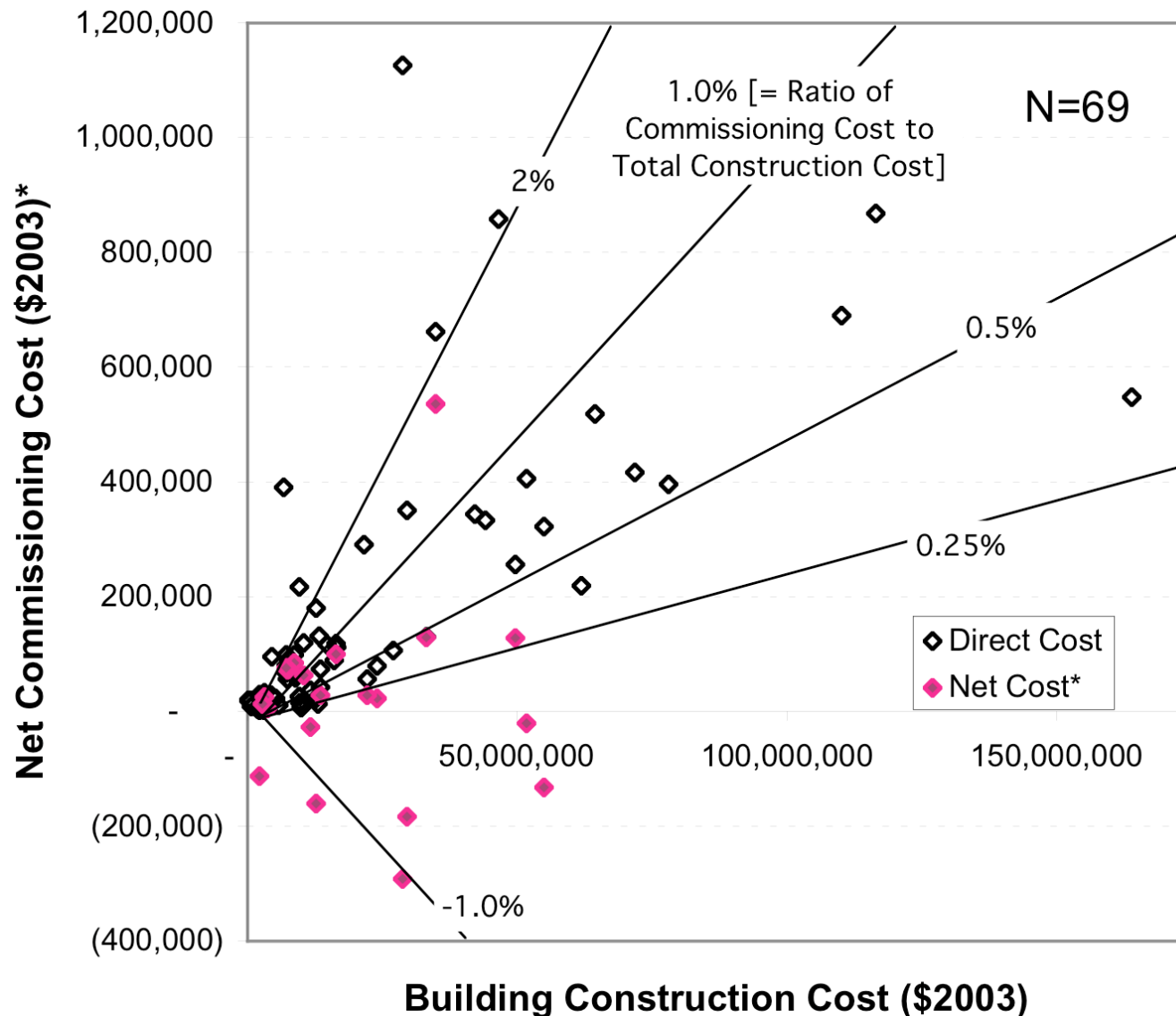
Value of Non-Energy Benefits Often Offsets Entire Cost of Commissioning

**\$2003
(1000s)**

20 projects



New Construction: Costs range from -1% to 2%+ of total construction cost



Inclusion of non-energy benefits (e.g. equipment downsizing, reduced callbacks, ... significantly reduces costs

National Potential; National Need

- **National potential:**
 - Assuming median savings of 15%
 - \$18 billion annual energy savings potential (US-wide) -- *plus* non-energy benefits
- **National need:**
 - Without commissioning, many energy-efficiency projects, programs, and policies will often fall short of their goals

Recommendations

- Cx is needed, and is a good investment, with significant energy savings and other benefits
- No energy management program is complete without commissioning (in-house or out-sourced)
- Invest in commissioning and institutionalize the process > track outcomes > refine process
- Develop “Green Building Commissioning”

Participate in our Research:

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<http://eetd.lbl.gov/emills/PUBS/Cx-Costs-Benefits.html>

Existing Buildings vs. New Construction

- **Existing buildings**
 - larger
 - greater normalized energy savings
 - more cost-effective (excluding NEBs)
- **New construction**
 - less comprehensive
 - normalized costs higher
 - larger non-energy benefits
 - NEBs are a more important motivation for embarking on commissioning, and can go farther in offsetting the cost of commissioning
 - more deficiencies found